Study On Ultimate Resistance Formula Of High-strength Frictional Bolted Joints Made Of High-strength Steel

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Tensile Tests and Applicability of Conventional Design Formulas to SBHS Joints

BACKGROUND

Further structural rationalization of steel bridges such as weight reduction of members is realizable by utilizing high strength steel, and it leads to improve the productivity and constructability of bridge. Recently, a type of HSS called SBHS was developed in Japan. It has high strength and weldability and has already been specified in Japanese Industrial Standards (**Fig. 1**).

However, since the yield-to-tensile strength ratio is higher than 0.90, connected members' failure occurs before the gross area members have been plastic-deformed sufficiently. Additionally, it is unknown whether the resistance of high-strength steel joints can be estimated with the conventional design resistance formula for mild steel.

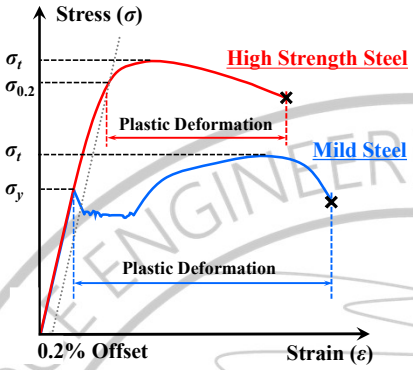

Fig. 1 Stress-strain curves of HSS

METHOD

In this study, we conducted tensile tests (**Fig. 2**) of frictional bolted joints made by SBHS, a type of HSS recently developed in Japan, to compare SBHS joint's maximum load with the ultimate designed resistance for mild steel.

A survey on experimental data (168 specimens) described in international (EC3, AASHTO LRFD) and Japanese journals (Architectural Institute of Japan (AIJ)) is also conducted. The survey focuses on friction-type double-lap joints with high-strength bolts and the bolt arrangement is limited to a single-row array, such as the specimens shown in **Fig. 2** . There is no restriction on faying surface treatments, steel and bolt grades, introduced tension of bolts, bolt columns and geometrical dimensions. However, the joint with any clearance between the connected and splice plates was not targeted like a pinned connection.

Fig. 2 Tensile test of joints made of SBHS

KEYWORDS

HSS; Frictional bolted joints; Ultimate resistance.

RESULTS

Fig. 3 compared the obtained maximum load P_{max} and the designed ultimate resistance P_{ud} for typical failure modes, by depicting the ratio P_{max}/P_{ud} of all data and the average and 90% prediction band of each actual failure mode.

$$P_{ud} = \min[\, P_{esd}, P_{tmd}, P_{bod} \,]$$

① Plate shear failure P_{esd}

② Net cross-section failure P_{tmd}

③ Bolt shear failure P_{bod}

The figure below **Fig. 3** shows the break lines considered in the resistances calculation.

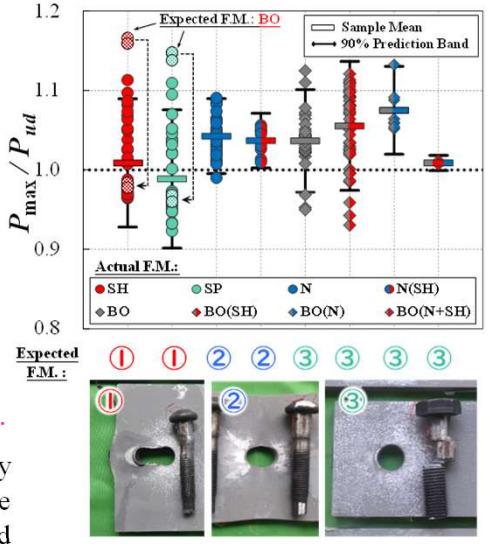

Fig. 3 P_{max}/P_{ud} for each failure mode

Because mode SH and SP showed a relatively large variation in comparison to other modes, the survey on experimental data of joints made of mild steel or overseas HSS is conducted to investigate the ratio P_{max}/P_{ud} of these modes (**Fig. 4**). The resistances are calculated with formulas specified in Japanese(AIJ) and international (EC3, AASHTO) design codes.

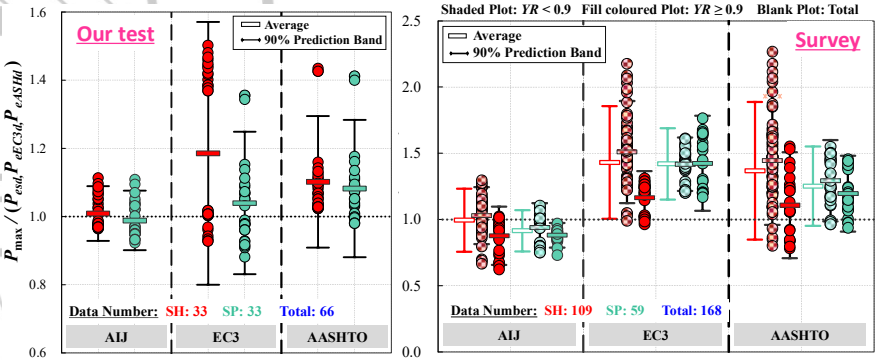

Fig.4 Survey on experimental data

SUMMARY

(1) It is concluded that existing design formulas can also be applied to SBHS joints.

(2) Ultimate resistance in joints with single row array and a couple of bolts can be moderately estimated by the 5% lower prediction limit P_{esd} while not perfect.

(3) The maximum bearing strength can be increased from the current value of about 2.5 σ_t, as the estimation accuracy of bearing resistances depended on P_{eEC3d}, P_{eASHd} varied depending on the parameter α_b in equation which has an upper limit of one.